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U.S. Department of Energy
Idaho Operations Office

Phase I Monitoring Well and Tracer Study Report for Operable Unit 3-13, Group 4, Perched Water

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ABSTRACT

This report presents the results of fieldwork performed to date at the Idaho Nuclear Technology and Engineering Center (INTEC) for Phase I of the Waste Area Group 3, Operable Unit 3-13, Group 4, Perched Water remedy. The work was performed as outlined in the Group 4 work plan, entitled *Monitoring System and Installation Plan for Operable Unit 3-13, Group 4, Perched Water Well Installation* (MSIP; DOE-ID 2000a). The Group 4 fieldwork completed to date includes the drilling and installation of the Phase I vadose zone monitoring wells, the collection and analysis of one round of perched water samples, and the completion of 25 weeks of the Phase I tracer study. Completion of these activities fulfills the scope of work for Phase I field activities, as specified in the MSIP. Results from these activities are presented in this report.

Because the tracer dye has not yet been detected in the Snake River Plain Aquifer beneath INTEC, which is a major objective of the study, the tracer study has been extended through June 2002. In addition, because the Big Lost River was not flowing during the summer of 2001, tracer studies for the Big Lost River infiltration have been postponed until sufficient flow is present. After the tracer study is completed in June 2002, this report will be revised in the fall of 2002 to update the extended tracer study results and data analysis activities and to finalize the Phase II new well construction plans.

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ACRONYMS

amsl	above mean sea level
bgs	below ground surface
BLR	Big Lost River
CFA	Central Facilities Area
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	contaminant of concern
DOE	Department of Energy
DOE-ID	U.S. Department of Energy Idaho Operations Office
DQO	data quality objective
FFA/CO	Federal Facilities Agreement/Consent Order
GAC	granular activated carbon
HI	hazard index
HLLW	high-level liquid waste
ICPP	Idaho Chemical Processing Plant
INEEL	Idaho National Engineering and Environmental Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
LSIT	Large-Scale Infiltration Test
MCL	maximum contaminant level
MSIP	monitoring system and installation plan
MW	monitoring well
ND	non-detect
OU	operable unit
OUL	Ozark Underground Laboratory
PSQ	principal study question
PW	perched water

RCT	radiological control technician
RD/RA	remedial design/remedial action
RI/BRA	remedial investigation and baseline risk assessment
RI/FS	remedial investigation/feasibility study
ROD	record of decision
SAA	satellite accumulation area
SOW	statement of work
SRPA	Snake River Plain Aquifer
SVOC	semi-volatile organic compound
TPR	technical procedure
TTLT	Tracer Test Laboratory Trailer
USGS	U.S. Geological Survey
VOC	volatile organic compound
WAG	waste area group
WGS	Waste Generator Services
WINCO	Westinghouse Idaho Nuclear Company

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1. INTRODUCTION

The Idaho National Engineering and Environmental Laboratory (INEEL) is divided into 10 waste area groups (WAGs) to better manage environmental operations mandated under the Federal Facilities Agreement/Consent Order (FFA/CO) (U.S. Department of Energy-Idaho Operations Office [DOE-ID] 1991). The Idaho Nuclear Technology and Engineering Center (INTEC) at the INEEL is designated as WAG 3, and Operable Unit (OU) 3-13 encompasses the entire INTEC facility except for the tank farm.

OU 3-13 was investigated to identify potential contaminant releases and exposure pathways to the environment from individual sites as well as the cumulative effects of related sites. Ninety-nine release sites were identified in the OU 3-13 remedial investigation/feasibility study (RI/FS), of which 46 were shown to have a potential risk to human health or the environment (DOE-ID 1997a). In addition, a new operable unit, OU 3-14, was created to specifically address activities at the INTEC Tank Farm area, where special actions will be required. The 46 sites were divided into seven groups based on similar media, contaminants of concern (COC), accessibility, or geographic proximity. The OU 3-13 record of decision (ROD) (DOE-ID 1999) identifies remedial design/remedial action (RD/RA) objectives for each of the seven groups. The seven groups are:

- Tank Farm Soils (Group 1)
- Soils Under Buildings and Structures (Group 2)
- Other Surface Soils (Group 3)
- Perched Water (Group 4)
- Snake River Plain Aquifer (Group 5)
- Buried Gas Cylinders (Group 6)
- SFE-20 Hot Waste Tank System (Group 7).

The final ROD for OU 3-13 was signed in October 1999 (DOE-ID 1999). The ROD presents the selected remedial actions for the above groups and specifically provides for Group 4 perched water monitoring to assess the perched water drain-out and contaminant flux into the Snake River Plain aquifer (SRPA).

As a result, a monitoring system and installation plan (MSIP) (DOE-ID 2000a) was developed to identify and describe in detail the work elements required to implement the selected remedies presented in the ROD. In turn, a field sampling plan (DOE-ID 2000b), a tracer test plan (DOE-ID 2000c), and a long-term monitoring plan (DOE-ID 2000d) were developed to implement the MSIP. This report presents data collected as a result of those plans through October 15, 2001 (that is, Phase I of the Group 4 monitoring and tracer study).

1.1 Regulatory Background

Under the FFA/CO (DOE-ID 1991), the U.S. Environmental Protection Agency, the Idaho Department of Environmental Quality, and the U.S. Department of Energy (DOE) (collectively known as the Agencies) are directing cleanup activities to reduce the risks to human health and the environment to acceptable levels at INTEC. Several phases of investigation have been performed at the WAG 3 OUs. For example, a comprehensive remedial investigation/feasibility study (RI/FS) (DOE-ID 1997a, 1997b, 1998) was conducted for OU 3-13 to determine the nature and extent of contamination and corresponding potential risk to human health and the environment under various exposure pathways and scenarios.

The INTEC perched water does not currently pose a direct human health and/or environmental threat. This perched water exists primarily as a result of INTEC water usage. The effects of the several potential sources are being evaluated as part of this investigation, including the percolation ponds, the sewage treatment lagoons, and the Big Lost River (BLR). The perched water is not used as a source of drinking water and is expected to disappear when INTEC operations cease. However, perched water does pose a potential threat as a contaminant transport pathway to the SRPA. The perched water zone may impact SRPA groundwater quality, since the perched water zone is a contaminant transport pathway between contaminated surface soils and the SRPA. Although a future water-supply well screened in the perched water is not capable of providing sufficient water for domestic use, restrictions will be required to prevent any attempts to use perched water after 2095, when INEEL-wide institutional controls are projected to end. The remedial action objectives for perched water, as stated in the ROD (DOE-ID 1999), are:

1. "Prevent migration of radionuclides from perched water in concentrations that would cause SRPA groundwater outside the INTEC security fence to exceed a cumulative carcinogenic risk of 1×10^{-4}, a total hazard index (HI) of 1, or applicable State of Idaho groundwater quality standards such as maximum contaminant levels (MCLs) in 2095 and beyond.

2. Prevent excavations into and drilling through the contaminated earth materials remaining after the desaturation of the perched water, to prevent exposing the public to a cumulative carcinogenic risk of 1×10^{-4}, a total HI of 1, and protection of the SRPA to meet Objective 3a listed above."

A response action is necessary to minimize or eliminate the leaching and transport of contaminants from the perched water to the SRPA and to prevent future perched water use.

1.2 Selected Remedy

The selected remedy for Group 4 (perched water) is institutional controls with aquifer recharge control. As described and defined by the OU 3-13 ROD, this remedy includes:

1. "Implement institutional controls (to include a DOE-ID Directive limiting access) to prevent perched water use while INTEC operations continue and to prevent future drilling into or through the perched zone (through noticing this restriction to local county governments, Sho-Ban Tribal Council, General Services Administration, Bureau of Land Management, and other agencies as necessary)."

   Implementation: This remedy is being implemented through the institutional control plan for WAG 3 OU 3-13 (DOE-ID 2001) identified and described in the OU 3-13 RD/RA Statement of Work (SOW).

2. “Implement remedies to control surface water recharge to perched water beneath INTEC by specifically taking the existing INTEC percolation ponds, which are estimated to contribute ~70% of the perched water recharge, out of service. Limiting infiltration to the perched water will minimize potential releases to the SRPA by reducing the volume of water available for contaminant transport. Design, construct, and operate replacement ponds outside of the INTEC perched water area following the removal of the existing INTEC percolation ponds from service. The replacement percolation ponds will be sited ~3,048 m (10,000 ft) southwest of INTEC and will be operational on or before December 2003.”

   Implementation: This remedy is being implemented through the INTEC Service Wastewater Discharge Facility Project (INEEL/EXT-99-00904).

3. “In addition, minimize recharge to the perched water from lawn irrigation, and lining the Big Lost River segment contributing to the INTEC perched water zones, if additional infiltration controls are necessary. Implement additional infiltration controls if the recession of the Perched Water zone does not occur as predicted by the RI/FS vadose zone model within five years of removing the percolation ponds. If implementation of the additional infiltration controls is necessary, implement as a second phase to the Group 4 remedy.”

   Implementation: A decision on whether this remedy is needed will be based on data collected during the five years of monitoring following the relocation of the percolation ponds. This monitoring is described in the MSIP (DOE-ID 2000a).

4. “Measure moisture content and COC concentration(s) in the perched water zones to determine if water contents and contaminant fluxes are decreasing as predicted. Also use these data to verify the OU 3-13 vadose zone model and determine potential impacts to the SRPA.”

   Implementation: The MSIP (DOE-ID 2000a) describes and defines the activities intended to meet Item 4 of the remedy for Group 4. The MSIP will measure moisture content, water levels, and COC concentrations in the perched water to determine if water levels, perched water extent, and contaminant fluxes are decreasing as predicted by the OU 3-13 vadose zone model and to provide aquifer recharge control from the INTEC perched water bodies. These data will then be used to determine potential impacts to the SRPA. Data collected and analyzed will be used to determine the need for additional infiltration controls beyond the scope of the MSIP.

1.3 Report Organization

This report is organized to facilitate the readers’ understanding, and maximize the usefulness, of data gathered through October 15, 2001, as part of the Group 4 monitoring well and tracer study. The report presents information about the study in the following order:

- Site Description and Background (Section 2)
- Phase I Drilling and Well Installation Program (Section 3)
- Site Stratigraphy (Section 4)
- Perched Water (Section 5)
- Chemistry (Section 6)

- Tracer Test (Section 7)
- Deviations from Work Plan and Evaluation of Data Quality Objectives (Section 8)
- Future Work (Section 9).

1.4 Report Status

This report is submitted to provide the Agencies with a status of the WAG 3, Group 4, Phase I work completed through October 15, 2001. Because fieldwork for the extended tracer study is continuing and evaluation of the data generated to date is not complete, this document should be considered as an interim status report. A revision to this document completing the data summaries and evaluation will be provided in the fall of 2002 following completion of the extended tracer test.

The revision to this document will include summaries of all data collected in support of the *Field Sampling Plan for Operable Unit 3-13 Group 4, Perched Water Well Installation* (DOE-ID 2000b) and the *Tracer Test Plan for Operable Unit 3-13 Group 4 Perched Water* (DOE-ID 2000c). The data summaries in the updated document will include all groundwater sampling results, subsurface sediment sampling results (not summarized in the current document), and complete tracer study results. The report will also provide an evaluation of the tracer study results, soil and groundwater results and trends, and updated site stratigraphy. These new data will be utilized to update the site conceptual model and planning for the Phase II monitoring network.

2. SITE DESCRIPTION AND BACKGROUND

2.1 Site Background

The INEEL is a U.S. Government-owned facility managed by the DOE. The INEEL is located in southeastern Idaho, and the eastern boundary of the INEEL is located 52 km (32 mi) west of Idaho Falls, Idaho. The INEEL site occupies approximately 2,305 km^2 (890 mi^2) of the northwestern portion of the Snake River Plain. The INTEC facility covers approximately 0.39 km^2 (0.15 mi^2) and is located in the south-central area of the INEEL, approximately 72.5 km (45 mi) from Idaho Falls (Figure 2-1).

INTEC has been in operation since 1952 and was previously known as the Idaho Chemical Processing Plant (ICPP), reflecting its original mission to reprocess uranium from defense-related projects and to research and store spent nuclear fuel. When the DOE phased out the reprocessing operations in 1992, it redirected the INTEC mission to (a) receive and temporarily store spent nuclear fuel and other radioactive wastes for future disposition, (b) manage current and past wastes, and (3) perform remedial actions.

The HLLW generated from past reprocessing of spent nuclear fuel was stored in an underground tank farm. The INTEC Tank Farm consists of eleven 1,135,624-L (300,000-gal) tanks, four 113,562-L (30,000-gal) tanks, and associated equipment for the monitoring and control of waste transfers and tank parameters. One of the 1,135,624-L (300,000-gal) tanks is empty and serves as a spare tank in the event of an emergency. The majority of wastes that were stored in the tank farm were raffinates generated during the first-, second-, and third-cycle fuel extraction processes.

Numerous Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites are located in the HLLW tank farm area and adjacent to the process equipment waste evaporator. Contaminants found in the interstitial soils of the tank farm are the result of accidental releases and leaks from process piping, valve boxes, and sumps and are also the result of cross-contamination from operations and maintenance excavations. No evidence has been found to indicate that the waste tanks themselves have leaked. The contaminated soils at the tank farm compose about 95% of the known contaminant inventory at INTEC. The final comprehensive OU 3-13 RI/FS (DOE-ID 1997b) contains a detailed discussion of the nature and extent of the contamination.

Formation of perched water zones is a result of discharges to the percolation ponds, natural flows from the BLR, discharge to the sewage treatment system infiltration galleries, and line losses from the facility water distribution system. The percolation ponds have come on line one at a time. The western pond, located directly south of INTEC (Pond 1), began receiving service waste in 1984. The eastern pond (Pond 2) came on line in 1986. The ponds have received all plant service wastewater since use of the injection well was discontinued in 1984. The two ponds received Resource Conservation and Recovery Act clean-closure equivalency for metals contamination in 1994 and 1995. Construction of new ponds to the southwest of the present facility is part of the remedy for Group 4, Phase I activities under the 1999 ROD but are outside the scope of this report.

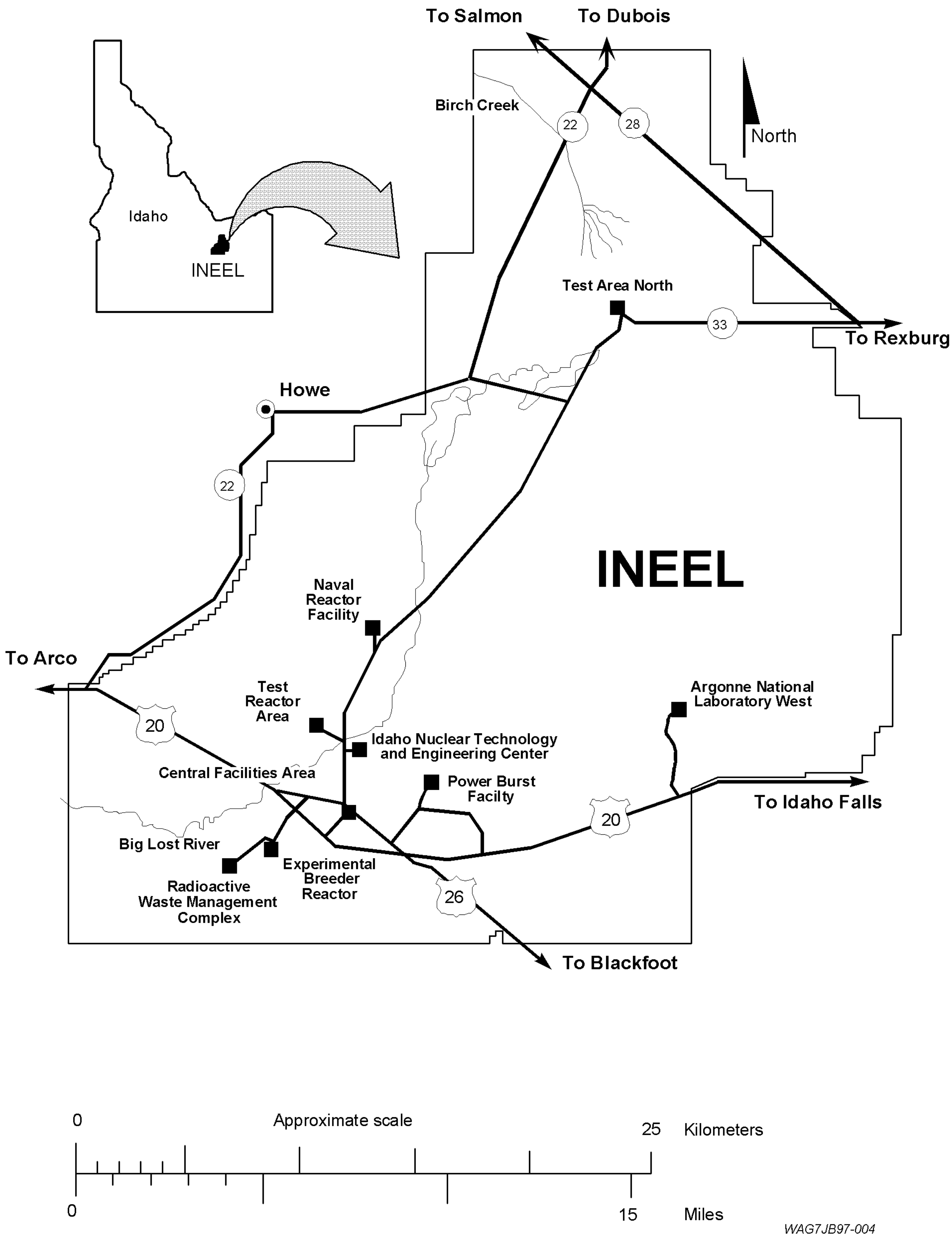

Figure 2-1. Map showing location of INTEC at the INEEL.

2.2 Conceptual Model

2.2.1 Geological Setting

The geology of the INTEC site includes about 13.7 m (45 ft) of surficial alluvium deposited during the Pinedale Glaciation about 12,000 to 35,000 years ago. The BLR is an intermittent stream that flows past the northwest corner of INTEC (upper left, Figure 2-2); flow is eventually lost by infiltration through the riverbed. Several thousand feet of relatively thin fractured basalt flows are underneath the alluvium, and sedimentary interbeds ranging in thickness from a few inches to several feet are interspersed between some of the basalt flows. Some of these interbeds are fairly continuous, while others are not. The SRPA is located at about 137 m (450 ft) below ground surface (bgs) at the INTEC site.

2.2.2 Hydrologic Setting

Several sources of water contribute to moisture movement and the development of perched water beneath INTEC. The major recharge source is the percolation ponds (bottom center, Figure 2-2). An average of 4.39 million liters (1.16 million gallons) of wastewater is discharged to the percolation ponds each day. Depending on the snowpack and precipitation that occurs in a particular year, the BLR may flow all year or cease to flow entirely for several months or years. Together, these two sources are thought to supply about 90% of the recharge (DOE-ID 1997, Appendix F). The wastewater treatment lagoons (upper right, Figure 2-2), operational activities, and precipitation account for the remaining recharge. Average annual discharge to the wastewater treatment lagoons is 52,617 m^3/yr (13.9 million gal/yr). Operational losses of water supply are variable and not well quantified. The mean annual precipitation at the INEEL is approximately 21.5 cm/yr (8.5 in./yr). Usually, less than half of this occurs as snowfall. The collection of precipitation in local basins can supply substantial amounts of focused infiltration.

As the wetting front moves downward through the surficial sediments, it may move through contaminated sediments, where the contaminants may be mobilized and transported. The water continues its downward movement until it encounters an underlying fractured basalt flow, where it is likely to collect and move laterally along the sediment/basalt interface until it encounters preferential pathways that may be associated with a fracture network or permeable rubble zones between basalt flows. Most of the water in the basalt is believed to flow as a saturated front through high-permeability systems consisting of fractures and permeable interflow zones. This results in rapid water movement through the entire fractured basalt portion of the subsurface.

If the infiltrating water encounters sedimentary interbeds, the water may spread laterally. A permeability contrast between the interbed, the fractures, and basalt matrix causes the water to pond and spread. One result of this contrast is the development of perched water in association with the interbeds. The perching may occur either on the interbeds or dense basalt. However, most of the perched water at INTEC appears to be associated with the interbeds.

The extent to which water moves horizontally while vertically transiting the fractured basalts is uncertain. Water has been shown to move laterally several miles in the subsurface when sufficient water was available to support long lateral spread (Nimmo et al. 2001). Eventually, a percentage of water infiltrating at the surface of INTEC may reach the underlying SRPA if enough water volume is present.

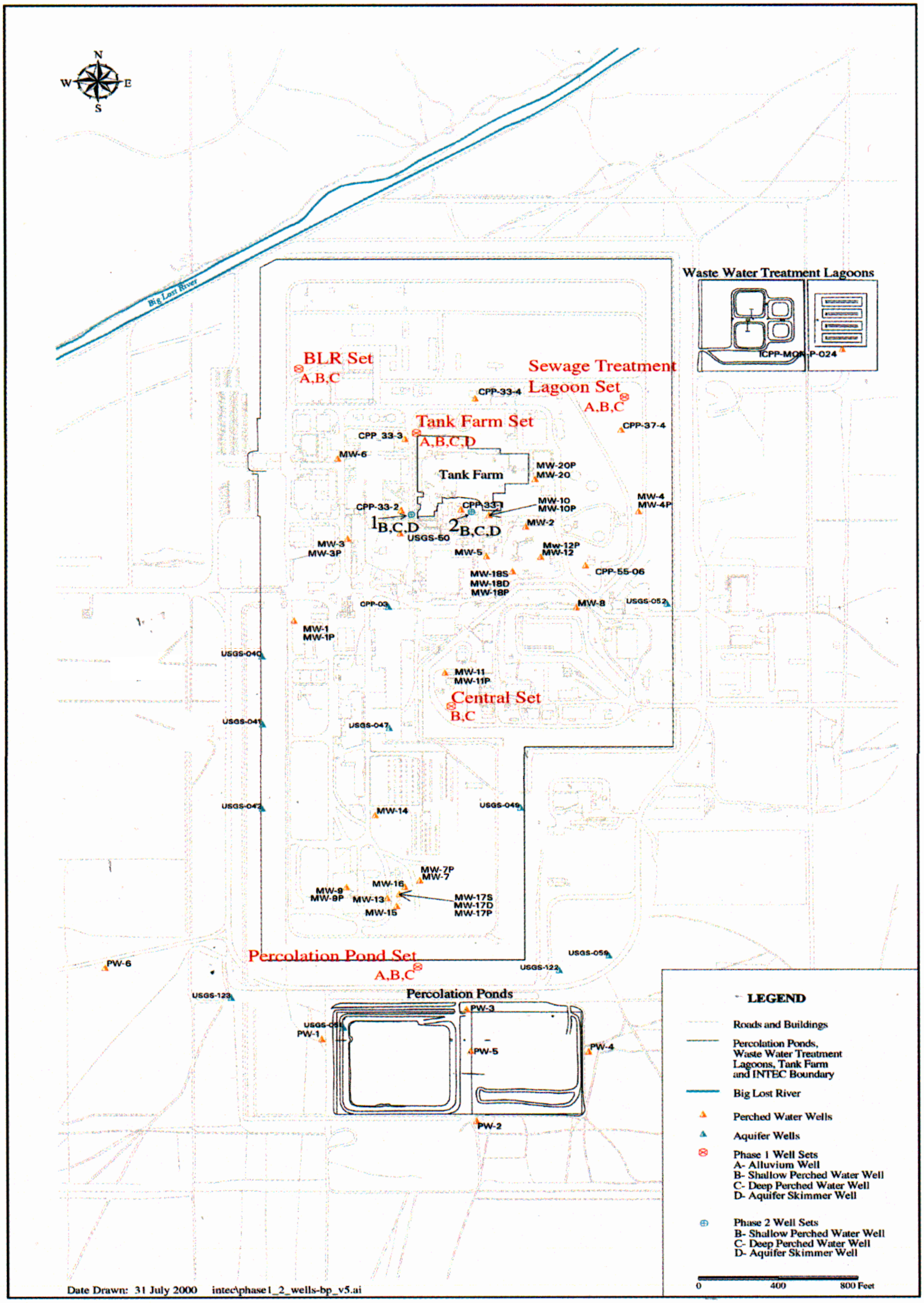

Figure 2-2. Map of INTEC with proposed Phase I well locations (from DOE-ID 2000b).

2.3 Perched Water

As mentioned earlier, perched water bodies are significant, because they increase the opportunity for contaminants to move both laterally and vertically in the vadose zone. This lateral water and contaminant movement in the vadose zone results in vertical migration rates that are spatially nonuniform beneath INTEC. Infiltration from the surface is assumed to move vertically through the basalt to an interbed. The water and contaminants migrate along the interbed and accumulate at interbed low points. This results in increased vertical water and contaminant fluxes in water accumulation areas and decreased vertical water and contaminant fluxes in the elevated portions of the interbed. Perched water bodies increase the complexity of flow and transport through the vadose zone.

Several discontinuous zones of perched water have developed in the vadose zone as a result of site operations and natural recharge sources (Figure 2-3). The perched water bodies have been found in three major zones in the subsurface:

- The interface between the surface alluvium and the shallowest basalt flow.
- An upper zone associated with the CD and DE3 interbeds at depths between 34 and 53 m (113 and 170 ft) bgs. This shallow zone is further subdivided into an upper shallow zone and a lower shallow zone.
- A lower zone associated with the DE6 and DE8 interbeds at a depth of about 97 to 128 m (320 to 420 ft) bgs.

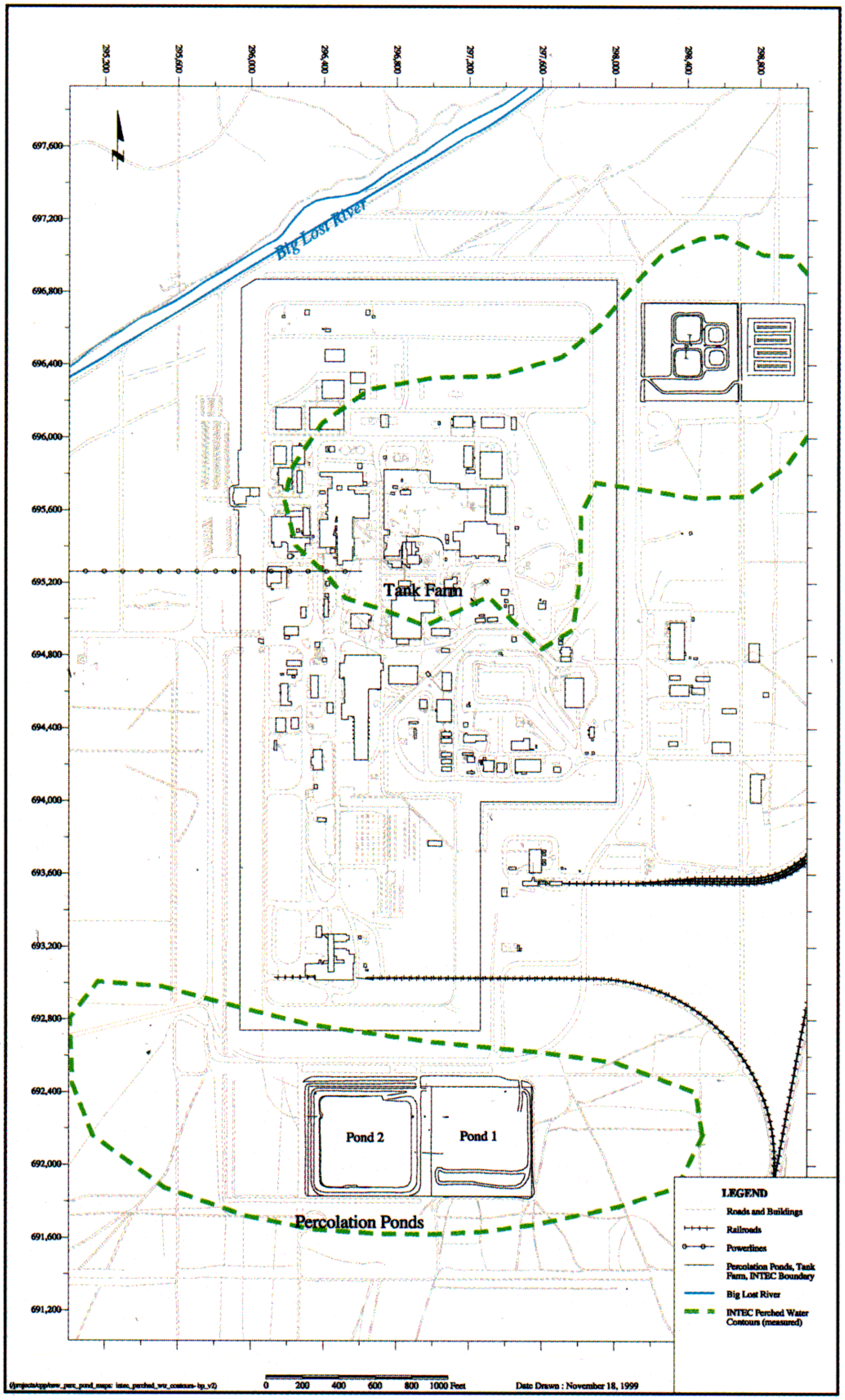

Figure 2-3. Approximate extent of shallow perched water identified in theWAG 3 RI/FS.

3. PHASE I DRILLING AND WELL INSTALLATION PROGRAM

Twenty-one new wells were drilled between November 16, 2000 and March 30, 2001 at the INTEC facility in order to provide additional data required by the WAG-3 OU 3-13 ROD (DOE-ID 1999). The purpose of constructing the new wells and collecting samples from them during their construction was to obtain data about the hydrologic system at INTEC. These wells were constructed as part of the Phase I Drilling and Well Installation Program, whose primary importance is to provide subsurface data and monitoring locations to help evaluate the hydrologic connection between recharge sources surrounding, and the perched water observed beneath, INTEC. The data collected during the Phase I drilling and subsequent monitoring will be used to finalize the Phase II monitoring program .

3.1 Drilling Summary

The OU 3-13 Group 4 well completion report, including as-builts and geological logs, is provided in Appendix A. The following is a summary of that report.

3.1.1 Summary of Well Construction and Completions

Five new well sets were constructed to assist in the evaluation of the INTEC subsurface. Each well set was designed to include wells to monitor the following zones:

- The base of the alluvial sediment
- The “shallow” perched water zone
- The “deep” perched water zone.

The HLLW tank farm set also included a monitoring well completed into the SRPA in addition to the well types listed above.

Figure 3-1 shows the new wells at INTEC, and Table A-3-1 in Appendix A summarizes the wells drilled and other relevant data, such as method of drilling and completion depths and types.

3.1.2 Selection of Locations and Intent of Well Placement

The primary criteria for the selection of the Phase I well set locations were that that they (a) be near known significant recharge sources or locations suitable for evaluating the effects of recharge sources on the perched water beneath the tank farm, (b) be completed in the primary perched water zones, and (c) support the tracer study. The primary recharge sources to be evaluated are the INTEC percolation ponds, the sewage treatment lagoons, and the BLR. Well sets were installed near each of these recharge sources, with a total of three wells and one corehole in each set. One well in each set was completed at the base of the surface alluvium (approximately 12 m [40 ft] bgs), one in the shallow perched water zone (approximately 33 to 43 m [110 to 140 ft] bgs), and one in the deep perched water zone (approximately 116 m [380 ft] bgs). A fourth well set was installed approximately midway between the percolation pond and tank farm, with wells completed in the shallow and deep perched water zones. During drilling, the alluvium was found to be wet and considerably thicker than average at this location. To monitor this zone, a well was installed in the alluvium at this set.

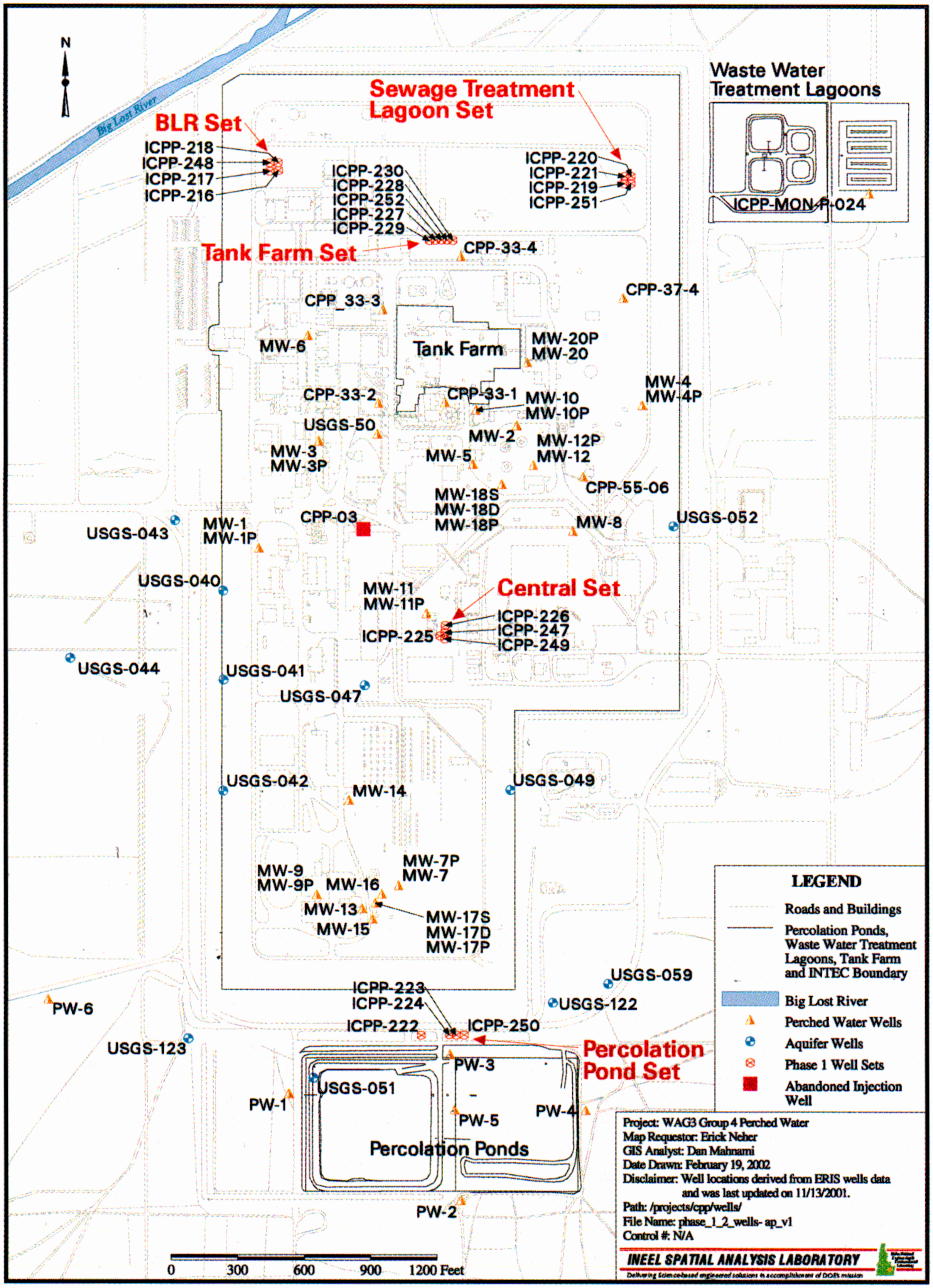

Figure 3-1. INTEC site map with new Phase I well locations.

Lastly, the fifth well set was installed north of the tank farm, with wells completed in the alluvium, in the shallow and deep perched zones, and at the top of the SRPA. These wells support the tracer study by providing perched water sampling points near each of the major recharge sources into which tracers will be injected. These wells will also support the Phase II monitoring program.

3.1.3 Well Completion and Instrumentation

Wells were drilled with a variety of completion types in order to measure different subsurface parameters in both saturated and unsaturated conditions.

3.1.3.1 Monitoring Well. Monitoring wells are used to monitor and sample zones of saturated conditions. Monitoring wells installed during Phase I activities had a 2-, 4-, or 6-in.-diameter, stainless-steel well casing and well screen. Water levels measured within INTEC wells are presented in Section 5 of this report.

3.1.3.2 Piezometer. Piezometers are constructed in a manner very similar to the monitoring wells. However, piezometers are normally constructed of PVC plastic, with a much smaller-diameter casing (1-in or 1.25-in) and are usually used only for measuring static water levels. If sampling is required, samples can often be retrieved through the use of a small-diameter micro-bailer. Piezometers typically have a short screened interval of only 0.3 to 0.6 m (1 to 2 ft).

3.1.3.3 Suction Lysimeter. Suction lysimeters are designed to collect soil water samples under either saturated or unsaturated conditions. To collect water, a vacuum is applied on the lysimeter's porous section that is in contact with the soil, and the soil water is drawn into the lysimeter body. Water is removed from the suction lysimeter by applying positive pressure to the suction lysimeter, thus pushing the collected water up a tube to the surface and into a sample container. The amount of water collected and the duration of collection is dependent on the available soil moisture, the soil water potential, the conductivity of the porous material in the lysimeter, and the vacuum applied.

3.1.3.4 Tensiometer. Tensiometers are used to measure the matric potential (pressure head) of a porous medium under unsaturated conditions or pressure head if saturated conditions form. Matric potential is used to calculate hydraulic gradients, determine the direction of soil water movement in the vadose zone, and calculate the rate of flow, given the hydraulic conductivity of the materials.

When the tensiometer is placed in unsaturated soil, water in the tensiometer equilibrates with the soil water in the surrounding soil. During equilibration, which may require several days, water is drawn from the tensiometer into the surrounding formation, and a change in pressure head occurs within the tensiometer. The pressure transducer measures the vacuum in the air/water column within the tensiometer to determine the matric potential of the surrounding medium. The measured vacuum or pressure is then electronically recorded on a data logger located at each well set. These data can then be downloaded in electronic form either in the field or by dial-in modem. Each well set data logger records data from several different tensiometers and stores the data in separate data channels.

Data from the various installed tensiometers are shown graphically in Section 5 of this report.

3.1.3.5 Temperature Sensors. Temperature sensors are attached to many of the tensiometer installations in the various well sets to record the down-hole temperature at a specific depth zone. An air temperature sensor was also installed at the BLR well set. These temperature data are also recorded to the data loggers and can be accessed at the same time as the tensiometer pressure/vacuum data.

3.1.4 Previous Well Completions

Several previously constructed INTEC wells also monitor the perched water zones at the INTEC facility. Completion data for these wells are included as Table 3-1.

3.2 Sample Collection and Analysis

3.2.1 Corehole Drilling

In addition to the wells constructed by air rotary methods, a corehole was drilled at each of the well set locations. This corehole enabled the collection of undisturbed interbed materials. The interbed materials were analyzed for physical and hydrological characteristics as well as for chemical characteristics and contamination.

3.2.1.1 Physical Properties. If sufficient material was available, three samples were collected from each interbed for physical and hydrologic property analysis. Samples were collected from the top, middle, and bottom of the interbed sediment unit. To provide the required sample data, the samples are required to be in an undisturbed condition for most of the requested analyses. Therefore, coring of the interbeds was accomplished with Lexan tube inserts in the core barrel system. The individual samples were then collected by cutting the Lexan liner and capping the ends. Efforts were made to minimize sample compaction during cutting and transport.

Physical and hydraulic analyses consisted of a moisture characteristic curve, grain size distribution, moisture content, effective porosity, bulk density, and saturated and unsaturated hydraulic conductivity.

3.2.1.2 Physical Properties Data. Physical properties data collected during Phase I drilling are presented in Table 3-2. Physical properties data had also been collected during the drilling of monitoring wells during the INTEC perched water investigation in 1993. The 1993 data are presented in Table 3-3. Additional hydraulic conductivity data were collected through aquifer testing on selected perched water wells during 1993 and 1994; these data are presented in Table 3-4.

3.2.1.3 Core Archive. Rock and sediment core collected during the drilling of Phase I wells was boxed and photographed. The photographs of the core are shown in Appendix B. After logging and photographing of the core, it was shipped to the U.S. Geological Survey (USGS) Lithologic Core Storage Library at the INEEL's Central Facilities Area (CFA). Table B-2-1 in Appendix B lists the INTEC coreholes and depth of core available for inspection or subsampling at the USGS core as well as core archived at the INTEC facility in the Radiologic Core Storage Library.

Table 3-1. Well construction summary from WAG 3 RI/FS (wells drilled before year 2000).

Well	Alias	Type	Northing (ft)	Easting (ft)	Land Surface Elevation (ft)	Measure Point Elevation (ft)	Total Depth Drilled		Well Screen (Footage)	
							Footage	Elevation	Top	Bottom
CPP-33-1	33-1	2-in. well	695392	296939	4915.2	4917.4	113.6	4801.6	89.0	99.0
CPP-33-2	33-2	2-in. well	695385	296639	4914.2	4915.4	114.7	4799.5	85.8	105.8
CPP-33-3	33-3	2-in. well	695806	296659	4913.7	4916.2	126.4	4787.3	111.8	121.8
CPP-33-4	33-4	2-in. well	696049	297011	4911.9	4914.0	124	4787.9	98.2	118.2
CPP-37-4	37-4	2-in. well	695861	297743	4911.0	4912.7	129.3	4781.7	99.9	109.9
CPP-55-06	55-06	2-in. well	695057	297563	4911.6	4913.2	122.9	4788.7	93.1	113.1
INTEC-MON-P-001 (4 in.)	MW-1-4	4-in. well	694731	296099	4916.5	4919.3	395	4521.5	326.0	336.0
INTEC-MON-P-001 (1 in.)	MW-1-1	1-in. piezo	694731	296099	4916.5	4919.0	395	4521.5	359.0	369.0
INTEC-MON-P-002	MW-2	2-in. well	695285	297262	4913.1	4916.1	127	4786.1	102.0	112.0
INTEC-MON-P-003 (2 in.)	MW-3-2	2-in. well	695215	296369	4916.0	4918.5	151.3	4764.7	128.0	138.0
INTEC-MON-P-003 (1 in.)	MW-3-1	1-in. piezo	695215	296369	4916.0	4918.5	151.3	4764.7	116.3	118.0
INTEC-MON-P-004 (2 in.)	MW-4-2	2-in. well	695376	297828	4911.4	4914.2	131	4780.4	100.6	110.6
INTEC-MON-P-004 (1 in.)	MW-4-1	1-in. piezo	695376	297828	4911.4	4913.8	131	4780.4	128.0	129.7
INTEC-MON-P-005	MW-5	2-in. well	695110	297064	4916.4	4919.3	141	4775.4	106.5	126.5
INTEC-MON-P-006	MW-6	2-in. well	695690	296320	4916.5	4919.3	161	4755.5	117.0	137.0
INTEC-MON-P-007 (2 in.)	MW-7-2	2-in. well	693209	296726	4917.4	4920.1	177	4740.4	132.0	142.0
INTEC-MON-P-007 (1 in.)	MW-7-1	1-in. piezo	693209	296726	4917.4	4920.1	177	4740.4	102.3	104.0
INTEC-MON-P-008	MW-8	2-in. well	694806	297514	4911.7	4914.4	141	4770.7	115.0	125.0
INTEC-MON-P-009 (2 in.)	MW-9	2-in. well	693168	296357	4919.6	4922.3	158	4761.6	120.0	130.0
INTEC-MON-P-009 (1 in.)	MW-9	1-in. well	693168	296357	4919.6	4922.3	158	4761.6	104.2	105.7
INTEC-MON-P-010 (2 in.)	MW-10-2	2-in. well	695356	297078	4914.7	4917.4	181	4733.7	141.0	151.0
INTEC-MON-P-010 (1 in.)	MW-10-1	1-in. piezo	695356	297078	4914.7	4917.4	181	4733.7	76.5	78.0
INTEC-MON-P-011 (2 in.)	MW-11-2	2-in. well	694435	296854	4919.9	4920.7	150.5	4769.4	131.0	136.0
INTEC-MON-P-011 (1 in.)	MW-11-1	1-in. piezo	694435	296854	4919.9	4920.7	150.5	4769.4	112.0	113.5

Table 3-1. (continued).

Well	Alias	Type	Northing (ft)	Easting (ft)	Land Surface Elevation (ft)	Measure Point Elevation (ft)	Total Depth Drilled		Well Screen (Footage)	
							Footage	Elevation	Top	Bottom
INTEC-MON-P-012 (2 in.)	MW-12-2	2-in. well	695107	297336	4913.0	4916.0	153	4760	109.0	119.0
INTEC-MON-P-012 (1 in.)	MW-12-1	1-in. piezo	695107	297336	4913.0	4916.0	153	4760	148.6	150.3
INTEC-MON-P-013	MW-13	2-in. well	693106	296561	4919.9	4922.0	128	4791.9	100.0	105.0
INTEC-MON-P-014	MW-14	2-in. well	693594	296503	4919.1	4921.6	138	4781.1	94.0	104.0
INTEC-MON-P-015	MW-15	2-in. well	693059	296608	4918.9	4921.3	143	4775.9	111.3	131.3
INTEC-MON-P-016	MW-16	2-in. well	693173	296648	4919.1	4921.7	126	4793.1	97.0	107.0
INTEC-MON-P-017 (2 in.)	MW-17-2	2-in. well	693209	296726	4918.3	4921.1	381	4537.3	181.7	191.7
INTEC-MON-P-017 (1 in.)	MW-17-1	1-in. piezo	693209	296726	4918.3	4921.1	381	4537.3	263.8	273.8
INTEC-MON-P-017 (4 in.)	MW-17-4	4-in. well	693209	296726	4918.3	4921.1	381	4537.3	360.0	381.0
INTEC-MON-P-018 (2 in.)	MW-18-2	2-in. well	695020	297193	4914.0	4917.32	494	4420	105.0	115.0
INTEC-MON-P-018 (1 in.)	MW-18-1	1-in. piezo	695020	297193	4914.0	4917.33	494	4420	394.0	414.0
INTEC-MON-P-018 (4 in.)	MW-18-4	4-in. well	695020	297193	4914.0	4917.31	494	4420	459.0	479.0
INTEC-MON-P-020 (2 in.)	MW-20-2	2-in. well	695568	297309	4915.0	4917.0	151.5	4763.5	133.2	148.4
INTEC-MON-P-020 (1 in.)	MW-20-1	1-in. piezo	695568	297309	4915.0	4917.0	151.5	4763.5	96.0	106.0
PW-1	PW-1	6-in. well	692272	296235	4917.8	4919.13	120	4797.8	100.0	120.0
PW-2	PW-2	6-in. well	691791	297011	4917.0	4918.54	131	4786	111.0	131.0
PW-3	PW-3	6-in. well	692448	296961	4916.7	4918.12	125	4791.7	103.0	123.0
PW-4	PW-4	6-in. well	692198	297573	4914.8	4918.3	150	4764.8	110.0	150.0
PW-5	PW-5	6-in. well	692199	296981	4916.4	4918.4	131	4785.4	109.0	129.0
PW-6	PW-6	6-in. well	692697	295151	4920.5	4922.34	135	4785.5	105.0	125.0
USGS-43	USGS-43	4-in. well	694857	295720	4916.1	NA	675	4241.0	450.0	675.8
USGS-44	USGS-44	4-in. well	694237	295250	4917.9	NA	650	4267.0	461.0	650.0
USGS-50	USGS-50	4-in. well	695249	296636	4913.5	NA	405	4508.5	356.0	405.0

Table 3-2. Hydrological data from Phase I drilling.

		Brass Cap Location								Selected Grain Size Percent by Weight						Calculated Unsaturated Hydraulic Properties			
Well Name	Well Alias	Northing (ft)	Easting (ft)	Elevation (ft)	INEEL Sample ID	Lab Sample ID	Sample Matrix	Depth or Depth Interval	Effective Porosity (% cm^3/cm^3)	Sand	Silt	Clay	Volumetric Moisture (%, cm^3/cm^3)	Saturated Hydraulic Conductivity (cm/sec)	Method	α (cm^{-1})	N	θ_r	θ_s
ICPP-SCI-P-216	BLR-AL	696438.07	296190.33	4913.64	PWD06801GX	PWD06801GX	Sediment	33-34	26.1	29.41	4.7	3.4	6.6	4.80E-02	Constant head	1.9868	1.2407	0.026	0.2555
ICPP-SCI-P-216	BLR-AL	696438.07	296190.33	4913.64	PWD06802 GX	PWD06802 GX	Sediment	34-35	31.9	13.26	6.4	6.9	21	1.10E-01	Constant head	1.2729	1.1024	0	0.4198
ICPP-SCI-P-226	CS-DP	694385.14	296942.09	4914.54	PWD09001 GX	PWD09001 GX	Sediment	10-10.5	21.9	32.29	1.8	3.1	11.7	6.90E-02	Constant head	0.3126	1.2521	0.0256	0.2864
ICPP-SCI-P-226	CS-DP	694385.14	296942.09	4914.54	PWD09401 GX	PWD09401 GX	Sediment	19-20	15.6	20.05	0.5	1.8	9.7	7.40E-03	Constant head	0.1123	1.5444	0.0516	0.2247
ICPP-SCI-P-226	CS-DP	694385.14	296942.09	4914.54	PWD09501 GX	PWD09501 GX	Sediment	45-46	24.5	51.8	7.8	12	22.3	6.60E-07	Falling head	0.0163	1.1881	0	0.401
ICPP-SCI-P-226	CS-DP	694385.14	296942.09	4914.54	PWD09601GX	PWD09601GX	Sediment	51-52	15.8	32.99	36.4	29.6	37.9	6.70E-08	Falling head	0.0002	1.3428	0	0.3851
ICPP-SCI-P-248	BLR-CH	696472.53	296150.93	4913.52	PWD06601 YH	PWD06601 YH	Sediment	10-10.5	27.8	16.01	1.9	1.8	4.8	3.80E-02	Constant head	0.1723	1.4687	0.0326	0.3321
ICPP-SCI-P-248	BLR-CH	696472.53	296150.93	4913.52	PWD06701 YH	PWD06701 YH	Sediment	18-18.5	30.2	41.21	4	4.1	5.3	4.70E-02	Constant head	0.0467	2.0252	0.0602	0.3696
ICPP-SCI-P-248	BLR-CH	696472.53	296150.93	4913.52	PWD07001 YH	PWD07001 YH	Sediment	87-87.5	19.5	2	70	28	45.6	1.00E-06	Falling head	0.0006	1.2776	0	0.4799
ICPP-SCI-P-248	BLR-CH	696472.53	296150.93	4913.52	PWD07201 YH	PWD07201 YH	Sediment	167.6-168.3	34.1	12.97	76.7	7.8	33.3	4.60E-05	Falling head	0.0045	1.2501	0	0.4533
ICPP-SCI-P-248	BLR-CH	696472.53	296150.93	4913.52	PWD 07201 GX	PWD 07201 GX	Sediment	167.6-168.3	29.1	48.7	42.1	8.9	35.8	4.70E-04	Constant head	0.0158	1.1925	0	0.44
ICPP-SCI-P-249	CS-CH	694325.31	296938.79	4914.48	PWD04401 GX	PWD04401 GX	Sediment	376-377.5	25.9	53.43	17.2	7.8	44.5	2.50E-06	Falling head	0.0008	1.3951	0	0.394
ICPP-SCI-P-249	CS-CH	694325.31	296938.79	4914.48	PWD04601 GX	PWD04601 GX	Sediment	381.8-382.8	24.2	53.39	33.2	11.8	26.1	8.00E-04	Constant head	0.0851	1.1797	0	0.3138
ICPP-SCI-P-249	CS-CH	694325.31	296938.79	4914.48	PWD04701 GX	PWD04701 GX	Sediment	387.1-388.2	37	36.39	48.5	14.9	28.5	9.90E-04	Constant head	0.0509	1.1683	0	0.5238
ICPP-SCI-P-249	CS-CH	694325.31	296938.79	4914.48	PWD04702 GX	PWD04702 GX	Sediment	387.1-387.2	22.8	24.06	49	22	38.3	7.50E-07	Falling head	0.0007	1.2883	0	0.434
ICPP-SCI-P-249	CS-CH	694325.31	296938.79	4914.48	PWD05101 GX	PWD05101 GX	Sediment	164.2-164.7	22.3	20.31	41.7	26.3	33.1	7.80E-04	Constant head	0.0003	1.3161	0	0.3921
ICPP-SCI-P-250	PP-CH	692537.23	297025.79	4916.59	PWD03001 GX	PWD03001 GX	Sediment	15-15.5	30.4	20.88	2.3	1.7	6.2	8.00E-02	Constant head	0.0124	2.3011	0.0316	0.2354
ICPP-SCI-P-250	PP-CH	692537.23	297025.79	4916.59	PWD03101 GX	PWD03101 GX	Sediment	26-26.5	31.1	28	2.3	2.6	9.5	1.00E-01	Constant head	0.2086	1.3291	0.0144	0.3745
ICPP-SCI-P-250	PP-CH	692537.23	297025.79	4916.59	PWD03201 GX	PWD03201 GX	Sediment	31-31.5	30	28.45	3.3	4.6	11.0	1.60E-02	Constant head	0.3134	1.2618	0.0192	0.3923
ICPP-SCI-P-250	PP-CH	692537.23	297025.79	4916.59	PWD03401 GX	PWD03401 GX	Sediment	110.8-111.45	44.3	54.69	33.7	4.6	26.6	3.30E-02	Constant head	0.105	1.2886	0.0685	0.6024
ICPP-SCI-P-250	PP-CH	692537.23	297025.79	4916.59	PWD03601 GX	PWD03601 GX	Sediment	122.2-122.9	31.1	10	75.2	14.8	42.2	3.10E-04	Constant head	0.0021	1.4487	0.0447	0.4758
ICPP-SCI-P-250	PP-CH	692537.23	297025.79	4916.59	PWD03701 GX	PWD03701 GX	Sediment	132.7-133.1	24.6	12.94	65.3	21.7	39.9	2.40E-04	Constant head	0.0023	1.2575	0	0.4724
ICPP-SCI-P-250	PP-CH	692537.23	297025.79	4916.59	PWD09701 GX	PWD09701 GX	Sediment	168-173.3	41.2	50.81	12.4	2.6	33.9	4.40E-03	Constant head	0.0972	1.1932	0	0.517
ICPP-SCI-P-250	PP-CH	692537.23	297025.79	4916.59	PWD09901 GX	PWD09901 GX	Sediment	170-170.9	38.8	54.58	28.1	3.4	33.9	8.20E-04	Constant head	0.0266	1.2199	0	0.5109
ICPP-SCI-P-250	PP-CH	692537.23	297025.79	4916.59	PWD03901 GX	PWD03901 GX	Sediment	384-385.1	52.3	64.54	29.2	5.9	20.7	1.50E-02	Constant head	1.6681	1.1352	0	0.5625
ICPP-SCI-P-250	PP-CH	692537.23	297025.79	4916.59	PWD04101 GX	PWD04101 GX	Sediment	384-384.4	24.9	32.6	55.5	11.9	33.8	4.60E-07	Falling head	0.0001	2.1085	0.0764	0.4442
ICPP-SCI-P-251	STL-CH	696380.04	297780.34	4909.73	PWD05401 GX	PWD05401 GX	Sediment	19-19.5	18.6	14.26	2.1	1.4	8.1	3.00E-02	Constant head	0.0197	4.2289	0.0622	0.3142
ICPP-SCI-P-251	STL-CH	696380.04	297780.34	4909.73	PWD05402 GX	PWD05402 GX	Sediment	19-19.5	21.4	24.32	2.4	1.9	10.2	2.70E-02	Constant head	0.123	1.327	0.0265	0.3477
ICPP-SCI-P-251	STL-CH	696380.04	297780.34	4909.73	PWD05501 GX	PWD05501 GX	Sediment	30.5-31	22.7	30.81	4.1	4.7	10.3	1.70E-02	Constant head	1.5208	1.1435	0	0.2677
ICPP-SCI-P-251	STL-CH	696380.04	297780.34	4909.73	PWD05701 GX	PWD05701 GX	Sediment	103-103.8	43.7	61.71	31	7	26.8	2.80E-02	Constant head	0.2005	1.1726	0	0.6049
ICPP-SCI-P-251	STL-CH	696380.04	297780.34	4909.73	PWD05901 GX	PWD05901 GX	Sediment	108.3-109.5	24.3	4.5	67.6	27.9	36.6	4.20E-03	Constant head	0.0076	1.1638	0	0.4847
ICPP-SCI-P-251	STL-CH	696380.04	297780.34	4909.73	PWD06001 GX	PWD06001 GX	Sediment	114-114.7	6.4	0.44	53.8	47.8	46.4	2.50E-07	Falling head	0.0001	1.3795	0	0.4934
ICPP-SCI-P-252	TF-CH	696123.08	296925.41	4912.36	PWD08301 GX	PWD08301 GX	Sediment	144.6-152.2	42.1	44.53	11	1.1	27.5	8.10E-03	Constant head	0.1212	1.1666	0	0.5116
ICPP-SCI-P-252	TF-CH	696123.08	296925.41	4912.36	PWD08501 GX	PWD08501 GX	Sediment	154.5-156.2	22.1	9.6	54	21	32.2	8.20E-07	Falling head	0.0003	1.3471	0	0.4226
ICPP-SCI-P-252	TF-CH	696123.08	296925.41	4912.36	PWD07901 GX	PWD07901 GX	Sediment	20-23	25.5	18.67	1	1.5	8.7	5.60E-02	Constant head	0.7955	1.2084	0	0.321
ICPP-SCI-P-252	TF-CH	696123.08	296925.41	4912.36	PWD08001 GX	PWD08001 GX	Sediment	26-27	18	20.92	2.5	2.9	8.5	4.40E-02	Constant head	0.0861	1.914	0.0642	0.2518
ICPP-SCI-P-252	TF-CH	696123.08	296925.41	4912.36	PWD08101 GX	PWD08101 GX	Sediment	41-42.5	24.1	32.67	3.1	1.8	8.7	6.10E-02	Constant head	0.159	1.5421	0.0432	0.2939

Table 3-3. Hydrological data from 1994 drilling projects at INTEC.

				Initial Moisture Content				
Sample Number	Well	Soil Type (geologic log)	Depth (ft)	Gravimetric (%, g/g)	Volumetric (%, cc/cc)	Dry Bulk Density (g/cc)	Calculated Porosity (%)	Ksat (cm/sec)
3PG10701PR	MW-3	Silty clay	117–119.3	32.8	42.5	1.29	52.5	8.90E-05
3PG11001PR	MW-4	Silty sand and gravel	108–109.3	35.9	49.2	1.37	50.2	1.60E-05
3PG11901PR	MW-7	Silt with fine gravel	113.5–114.5	22.7	32.5	1.44	47.0	1.30E-03
3PG12201PR	MW-8	Clay with silt	122.3–123.7	28	42.2	1.51	45.0	1.10E-05
3PG12801PR	MW-10	Sandy silt	110.3–111	39.5	50.2	1.27	54.0	1.00E-05
3PG13101PR	MW-11	Silty sand	113.7–115.3	29.5	43.7	1.48	45.9	1.20E-05
MW-4 105.1-105.6	MW-4	Silt	105.1–105.6	43.8	51.4	1.18	57.6	3.20E-05
MW-4 105.6-106.8	MW-4	Silt	105.6–106.8	50.8	56.8	1.12	60.9	6.70E-05
3PG11601PR	MW-6	Clay	110–111	33.4	48.3	1.45	47.8	3.00E-07
3PG12501PR	MW-9	Slay with silt	111.6–112.5	28.8	30.1	1.05	61.4	2.10E-03
3PG13201PR	MW-11	Clay	135.4–136	18.1	33.2	1.83	33.6	5.20E-08
3PG10801PR	MW-3	Silty clay	138–139	21.6	30.9	1.43	47.2	8.30E-04
3PG11701PR	MW-6	Silty sand	142–143	22.4	30.6	1.36	49.5	2.20E-03
3PG12601PR	MW-9	Silt with clay	148.7–149	9.5	12.7	1.34	50.3	3.40E-03
3PG10101PR	MW-1	Sand with silt	231.7–232.3	15.7	24.8	1.59	41.3	3.30E-04

Table 3-4. Hydrological data from pumping test.

Well	Test Zone (ft bgs)	Test Type	Material	Hydraulic Conductivity cm/sec	Hydraulic Conductivity ft/day
CPP 33-2	97.8–105.8	Pumping/recovery	Basalt	1.80E-03	5.00E+00
CPP 33-3	111.2–121.8	Pumping/recovery	Basalt	9.50E-04	2.70E+00
CPP 33-4	103.7–118.2	Pumping/recovery	Basalt	2.40E-03	6.70E+00
CPP 33-4	103.7–118.2	Pumping/recovery	Basalt	3.40E-03	9.60E+00
CPP 55-06	105.2–113.1	Pumping/recovery	Basalt	4.20E-04	1.20E+00
MW-1	326–336	Slug	Basalt	2.00E-04	5.67E-01
MW-2	107.9–112	Slug	Sandy clay interbed	3.70E-03	5.10E+00
MW-4	104.6–110.6	Slug	Silty sand and gravel interbed	3.86E-05	1.09E-01
MW-5	115–129.9	Slug	Basalt with small sandy clay interbeds	1.08E-03	3.06E+00
MW-6	140–151	Slug	Silty sand, fine grained interbed	1.30E-03	3.72E+00

4. SITE STRATIGRAPHY

Appendix B describes the subsurface stratigraphy at INTEC.